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(73) Proprietor: KIRJAVAINEN, Kari  
Kivenlahdenkatu 11 A 4  
SF-02320 Espoo(FI)

(72) Inventor: KIRJAVAINEN, Kari  
Kivenlahdenkatu 11 A 4  
SF-02320 Espoo(FI)

(74) Representative: Omming, Allan  
STENHAGEN PATENTBYRA AB Box 17 709  
S-118 93 Stockholm(SE)

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## Description

## BACKGROUND OF THE INVENTION

5 The invention relates to a dielectric film element for converting the energy of an electric or magnetic field into mechanical energy or for converting mechanical energy into electric energy, comprising a homogeneous elastic layer containing gas blisters or cells. The invention further relates to a procedure for manufacturing such a dielectric film element.

10 A dielectric film of this general type could be regarded as a capacitor having a dielectric constant determined by the gas contained in the blisters or bubbles. When a dielectric film is subjected to electrostatic or electromagnetic forces a physical movement is created and when the film is subjected to mechanical forces a corresponding change of electrostatic or electromagnetic fields is obtained. To accomplish such movements and changes the film must be extremely thin, say 10  $\mu\text{m}$  and still be able to be compressed and expanded under the influence of very small forces.

15 The obtainable force is dependent on the thickness of the film as defined by the formula below.

The bubble or cell structure should exhibit as little resistance as possible to mechanical movements and being operable as a carrier reflecting changes in forces which means that the shape of each bubble or blister is an essentially flat bubble in a plane transverse to the direction of the intended movement.

It is well-known in the art to use film shaped piezoelectric elements.

20 JP-59-27584, for example, discloses a high molecule porous piezoelectric unit capable of selecting high molecular substance as desired elastic modulus to be formed in a film and hollow state by forming a mesh structure which is formed of a high

molecular substance and piezoelectric inorganic fine particles. JP-56-47199 discloses another type of piezoelectric transducer of multilayered lamination type. A polymer piezoelectric film is provided with electrodes on both sides and folded. The respective folded layers are bonded by adhesive.

25 EP-A-0 089 770 discloses a film with piezoelectric and pyroelectric properties obtained by extruding a polymer, PVDF for example, stretching the extrudate and applying a corona discharge preferably at the place where stretching occurs. Electrodes are in contact with one or both of its surfaces. The film thus produced does not exhibit any blisters or bubbles and cannot be used as a dielectric film according to the invention.

30 Piezoelectric devices operate in dependence on the fact that the volume of the material used will change as the field changes and change the surrounding field as the volume is subjected to a change, i.e. it is always a question of deforming a solid material. The formulas used to define the piezoelectric phenomena only involve the physical constants of the solid material as such and not the dielectric constant of a carrier gas.

Other publications dealing with piezoelectric devices and, therefore, not fully applicable to the invention are

JP-A-5787188, (piezoelectric ceramics with uniformly distributed pores)

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## OBJECT OF THE INVENTION

45 The object of the present invention is to provide a dielectric and elastic film from which widely differing electromechanical devices and signal-measuring pick-up devices can be manufactured. In order to achieve the highest possible electrostatic and electromagnetic forces across an elastic film, it is essential that the film, or film layers, is/are as thin as possible. The electrostatic and electromagnetic forces are inversely proportional to the square of the distances between electrodes and current conductors. On the other hand, the disruptive strength of both the plastic film and the air bubbles embodied therein increase proportionally as the distances decrease (Paschen's law). It is possible to produce thin air bubbles and thin elastic material, as seen in the direction of film thickness, by stretching aerated or foamed film in both its longitudinal and transversal directions, such as to flatten the bubbles into the shape of flat discs.

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## SUMMARY OF THE INVENTION

The inventive dielectric film element is characterized in that said film has been stretched in two directions so as to flatten the blisters and form flat disk-like bubbles extending in a plane transverse to the direction of the intended movement and in that said film is at least partly coated with an electrically conductive layer on at least one surface of said layer.

The thickness of such films may be in the order of  $10 \times 10^{-6}$  m and the films may have a voltage strength of  $100 \times 10^6$  V/m. The electrostatic force across the film is directly proportional to the square of the voltage in said directions, and the attraction of the current loops produced on both sides of the film layer is directly proportional to the square of the current strength. In the case of the inventive film, such quantities as force, pressure, surface-area and film thickness, electric-field strength and voltage have the following relationship:

$$F = pA = \frac{\Sigma E^2 A}{2} = \frac{\Sigma U^2 A}{2h^2} \quad (I)$$

where A = the surface area of the film and h = the film thickness. The other quantities represented are identified by symbols familiar in physics.  $\Sigma$  is the dielectric constant, with the dimension F/m. As shown by the equation (I), the inventive film embodies a plurality of quantities. When the film is used as a part of an electric measuring circuit, it is therefore possible to observe a wide variety of causal relationships between mutually different variables. When the film has the aforesaid thickness of 10 microns, there will therefore be obtained a force of 100 kN at a voltage of 1 kV and a momentary force of 100 kN with the aid of the magnetic field and a current of 10 A. The distance travelled by respective quantities can be amplified, by superimposing several film layers, one upon the other.

Since the film structure is capacitive as well as inductive, power can be supplied to the film structure at the highest possible rate and with the minimum of power losses. Good mechanical and electrical properties are obtained when the film is manufactured from polypropylene, for instance, in addition to which high mechanical strength is obtained in other directions, except in the direction of film thickness, in which direction the film has the highest possible elasticity. The modulus of elasticity of the film can be regulated by regulating the size, shape and number of bubbles incorporated therein. This will also enable the wide resonance of the film to be adjusted in the thickness direction of the film structure. A multi-layered film structure of this kind can be used as a motional device or as a vibratory surface in a frequency range of 0-100 MHz.

Advantageous embodiments of the inventive film have the characteristic features set forth in the following claims.

The method by means of which the inventive dielectric film is manufactured is characterized by the steps of: - extruding a foamable plastics in a plastics processing machine to form a tube, gas blisters being formed due to the foaming at desired density throughout the tube, heating the tube, expanding the heated tube in two directions to obtain a desired wall thickness and orientation, metallizing the outer surface of the tube, and longitudinally cutting open the tube to form a film.

The aforesaid method is a continuous, so-called film-blowing process commonly used in the manufacture of plastic films. The techniques applied in the manufacture of capacitors and printed circuits are also applied for producing multi-layered films and for the manufacture of motional devices.

Other advantageous embodiments of the inventive method are characterized by the features set forth in the following claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with reference to exemplifying embodiments thereof illustrated in the accompanying drawings, in which

Figure 1 illustrates the basic structure of film constructed in accordance with the invention;

Figures 2a-2c illustrate one embodiment of the invention in which voltage and current electrodes are positioned in the multi-layer structure;

Figures 3a and 3b illustrate a second embodiment of the invention in the form of a multi-layer capacitive and inductive structure;

Figure 4 illustrates a third embodiment of the invention in the form of a motional device,

Figures 5a and 5b illustrate a fourth embodiment of the invention in the form of a surface having sonic activity;

Figure 6 illustrates a fifth embodiment of the invention intended for obtaining translatory wave motion; and Figure 7 illustrates a method of manufacturing film constructed in accordance with the invention.

## 5 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 illustrates a plastic matrix A which comprises the inventive dielectric film and which has been coated on both sides with as respective metal film B, which may be integral or pre-patterned. The plastic matrix may be made, for instance, of polypropylene and has embodied therein flat blisters or bubbles C, which have been configured by stretching the plastic matrix in two directions. The finished film product has a typical thickness of 10 microns.

Figure 2a illustrates a structure which is composed of the inventive film and in which the electrostatic and electromagnetic forces both act in mutually the same direction. Applied on both sides of the film 1 are printed conductors 2, through which electric currents I1 and I2 pass through points U1, U2, U3 and U2 to produce an electrostatic and electromagnetic force F through the layers forming the film structure, as indicated by the arrow. The force F is effective to contract the structure when the currents on different sides thereof are unidirectional (Figure 2b), and is effective to expand the structure when the currents are mutually counter-directional (Figure 2c), in which case the structure discharges.

Both the capacitance and the inductance will increase in inverse proportion as a function of film thickness, and consequently the electric resonance frequency of the structure is almost directly proportional to its thickness. By applying a constant d.c. voltage to one end of the quadruple shown in Figures 2b and 2c, it is possible to measure the variation in voltage caused by the variation of the film thickness at the other end of the quadruple.

In the case of motional devices or elements, an advantage is afforded when the flow of current ceases subsequent to charging the capacitance of the structure, and the continuous force and position can be maintained merely with the aid of the electric field. This will result in minimum power consumption. This effect can be achieved by controlling the quadruple in various ways, e.g. with the aid of d.c. or a.c. currents.

It is also necessary in the case of motional devices to obtain feedback from the extent of movement accomplished. This is achieved by measuring the capacitance of the structure, the time constant of the LC-circuit, the resonance frequency, or the phase shift between current and voltage at the measuring frequency applied together with the control voltage, e.g. from the same connections U1-U4 as those used to control the film.

When the capacitance changes, the voltage across the inductive component of the film structure will also change. The change in the input current may be measured as an alternative to measuring the change in voltage. These procedures can be used advantageously when the film structure is intended to receive sound waves in the audio frequency or ultrasonic range, for example.

Figure 3a illustrates a structure which comprises two films folded in superimposed relationship, such that the conductor pattern is interposed between two mutually equal films, the outer surfaces of which have been provided with a conductive coating. The inductance is produced in the manner indicated by the flux lines 3. It will be understood that the electrodes and conductors may be shaped and connected to the structure in a number of different ways. The film layers may be controlled separately, and the electrodes may be divided into blocks and each block separately controlled. The forces generated by the electric field or by the magnetic field may be used exclusively. The electrodes may also be shaped in a manner to produce given patterns, thereby obtaining corresponding deformations in the structure.

Figure 3b illustrates the equivalent circuit of the film element 4 of Figure 3a, and shows the series connection of the elements 4 resulting from folding said element.

Figure 4 illustrates a motional device which is composed of capacitive and inductive motional elements 5 of mutually different sizes and of the type aforementioned. The motional elements are controlled either connected in parallel or individually with the aid of an electronic unit 6. The electronic unit 6 comprises the electronic switches, transistors or thyristors used for control purposes, and also includes a microprocessor to which control commands are transmitted by a serial connection 7. control of the motional device by the electronic unit is divided, for instance, into four independent main blocks. These blocks are controlled so as to achieve motion in the X, Y and Z directions. The supply voltage 8 is taken to an electrolytic capacitor or storage battery unit 9, from which fast current surges can be drawn.

The motional device can be controlled with great accuracy, and the load variations automatically compensated for with the aid of the feedback principle based on the aforescribed film motion-measuring procedures. The motional elements 5 are advantageously controlled in an on/off fashion. Power losses will then be insignificant and only simple control electronics are required. The motional device has the form of a

relatively long lever arm and consequently small and precise movements are obtained by controlling the elements on the end of said arm. Inertia forces are also of a minimum. Expansive movement is achieved by controlling, for example, all elements of one half in rapid succession, so that control will start at the root of the motional device and proceed towards the tip thereof at a suitable rate, such as to minimize overshooting and the need for control energy. One important advantage afforded by this kind of motional device is that the electric charge of individual elements can be transferred to other elements or to the current source, while dissipating only little power in the process.

Motional devices of this kind are also light in weight, but nevertheless robust. The structure has a specific gravity of  $1 \text{ kg/dm}^3$  and, when in the shape of a cube, a force of 1 kN. The extent of movement is then about 2 cm in the longitudinal direction of the arm. The instantaneous power input to a structure of this kind may be almost infinite, when the inductance of the structure is minimized.

Figure 5a illustrates a film having a surface with motional and sonic activity 10. Such acoustic material may be glued to wall surfaces 11 and used as a loudspeaker or a microfon. The roll of film 12 per se may be used as a vibration source and receiver. An acoustic surface of this kind can be controlled with the aid of the aforesaid feedback means for measuring movement of the film. This will also enable high quality sound reproduction to be achieved. By measuring film movement with the aid of the aforesaid methods and by employing this measurement as a feedback signal in the film-controlling amplifier, said amplifier optionally being selective for given audio frequencies, it is possible to produce an acoustic surface which will reflect some frequencies and which is "soft" to other frequencies.

As illustrated in Figure 5b, the sound pressure acting on the film can also be measured with the aid of a piezoelectric film layer 13 placed on the insulating layer 14. In this instance, the signal is amplified by an amplifier 15 and is used as a feedback signal for the amplifier 16 controlling the surface having sonic activity 10. In this way, there is obtained from the sound pressure a feedback such that the sound pressure acting on the surface will precisely follow the controlling acoustic signal 17.

When the reference signal is zero, the surface will behave as a completely "soft" surface, since the circuit will tend to maintain the signal arriving from the measuring film 13 constantly at zero. It will be understood that a surface of this kind will reflect no sound whatsoever. When the amplifier 16 is selective, only sounds of given frequencies will be reflected from said surface. Such surfaces may be used to correct the acoustics in concert halls or for noise attenuation.

When controlling this kind of acoustic surface it is necessary to use a constant bias above and below which the control signal varies. The magnetic forces should be minimized unless the structure has been premagnetized, e.g. by magnetizing the outermost film layers. The surfaces will then comprise films which incorporate an abundant quantity of ferromagnetic powder. Premagnetization may be replaced, for instance, by a continuous d.c. current flowing in the circuit of another film surface. Said means may be used as a transmitter and receiver in the ultrasonic range, in addition to the audiofrequency range. Exceedingly high-powered ultrasonic pulses can be generated in the film, for instance pulses of  $100 \text{ kW/m}^2$ .

Figure 6 illustrates the control of an element or device having motional activity 18, for instance with the aid of a three-phase voltage, in a manner such as to produce translatory wave motion between the plates 19, such that a fluid 20 can be pumped with the aid of this wave motion. The pumping rate and the quantity of fluid pumped can be regulated by regulating the amplitude and frequency of the vibrations. The element possessing motional activity 18 may also be given a tubular configuration, and such tube systems may be used for pumping liquids. The devices producing said wave motion can also be used as motors for creating motion within a fluid, with the aid of said wave motion.

In addition to those applications mentioned above, the inventive film may also be used to take measurements on the basis of changes in capacitance. Since the capacitance of the film depends on its thickness, applications for measuring the effect of an external force with the aid of the changes occurring in the capacitance of the film will include, inter alia, pressure transducers or pick-ups, keys and press-button arrays. The film may also be used as a device for registering temperature changes, since the volume of the gas contained in the bubbles or blisters embodied in the film will change in response to the temperature, with the capacitance of the film also changing commensurately. On the basis of this phenomenon, the film may be used in temperature transducers or pick-ups and in apparatus based on heat radiation, such as infra-red radar apparatus and image-forming arrays which operate in the infra-red range, as well as in conjunction with liquids which vaporize at given temperatures.

When the film is made of a permanently chargeable and polarizable material, such as polytetrafluoroethylene, it is possible to construct devices from which a voltage is obtained in response to changes in film thickness, consistent with the capacitor law:  $Q = CU$ . When the charge of the film is constant, the capacitance changes which result from changes in film thickness are directly transformed into a voltage which acts across the film. This film can therefore be used to construct transformers in which a

primary film is operative to transfer energy to a secondary film with the aid of vibrations, for instance in the construction of parameter transformers in which, in combination with the inductance the secondary film will constitute a resonance circuit into which the primary film pumps energy, as known from parameter amplifier technology.

5 Identification of local changes taking place in the film can be achieved by configuring the film as a matrix board in which local changes in the film are caused, or recorded, on the edges of the film, e.g. by measuring impedance. Accordingly, the matrix board is composed of independently addressable elements which have an individual significance and code, e.g. individual to the computer with which the matrix is used. One example in this respect is the press button array beforementioned.

10 Another significant application is obtained when the gas incorporated in the film is ionized with the aid of an a.c. voltage, thereby enabling the film matrix to be used in image-forming matrix arrays.

Figure 7 illustrates schematically a method for manufacturing the inventive film, this method being a continuous two-step method.

The bubbles or blisters may be formed in the plastic matrix in two different ways. In so-called chemical 15 foaming, a foaming agent is admixed with the plastic, and, when heated, forms bubbles, e.g. nitrogen bubbles. In the case of so-called gas injection techniques, a gas such as freon is pumped into the plastic extruder, where said gas expands to form bubbles or pores when the pressure external of the extruder is lowered.

Figure 7 illustrates the nozzle 21 of a plastic extruder, and the arrow 22 indicates gas being pumped 20 into the extruder in accordance with the gas injection method. In a first step of manufacture there is extruded a tube 23 which has a wall thickness of approximately 0.4 mm. Spherical gas blisters or bubbles of about 10 micron in diameter have been formed at a spacing of 10 microns. Accordingly, approximately 20 bubbles or blisters are formed on top of each other over a distance equal to the wall thickness of the tube. The forming properties of the plastic improve with increasing degrees of crystallization, and for this reason 25 the extruded plastic is heat-treated in a manner suitable to promote crystallization, in the present case by cooling the plastic with the aid of a cooling member 24. A traction means 25 functions as a tube conveyor; the flattening of the tube accomplished by the traction means depicted in the figure is not indispensable. In the manufacturing procedure illustrated in Figure 7, the air blown through the nozzle 28 continues through the entire process.

30 In a second step of manufacture, the tube is heated in an oven 26, whereafter the tube is oriented biaxially and the desired wall thickness is imparted to the tube by blowing and drawing said tube 27 laterally to about five times and longitudinally about eight times, the diameter of the tube 23, thus reducing its wall thickness to about 10 microns. The blowing air or other gas is derived from the nozzle 28, the delivery pressure of said gas now being permitted to inflate the heated tube. As a result of proper heat- 35 treatment, the bubbles will not rupture and are instead flattened, while at the same time the matrix material separating said bubbles will stretch and become thinner without rupturing. The bubbles or blisters will be flattened during the course of expansion to about 0.25 micron in height, about 80 micron in length and about 50 micron in width. The additional theoretical voltage strength of the bubbles or blisters is in the order of 1600 V and that of the matrix material in the order of 2500 v, thereby enabling a d.c./a.c. tolerance of 40 1000 V to be readily achieved in a 10 micron film.

It should be noted that not all types of plastic materials require intermediate cooling and reheating of the tube 23. The purpose of this heat treatment is to enhance the degree of crystallization, and those plastics which undergo sufficient crystallization during conveyance following extrusion may be suitable for direct expansion, provided that it is ensured that their temperature is sufficiently high.

45 Finally, the film is wound on a reel for coating with a conductive material. Vacuum vaporization, sputtering or mechanical application can be used in this respect. It should also be borne in mind that the manufacture of a multi-layer film is conceivable in which the outermost layers consist of an electrically conductive plastic material which is already joined to the matrix plastic to be foamed at the method step in which the tube 23 is formed. In addition to the fact that the coating is necessary for accomplishing the 50 intended function of the inventive film, it is also important as an effective means in preventing the gas from escaping.

It will be obvious to one skilled in this art that the invention is not restricted to the described and illustrated and exemplifying embodiments thereof and that modifications may be made within the scope of the following claims. For instance, the main components of the film may be produced from the majority of 55 the thermoplastics with respect to matrix material, and the bubbles or blisters may be produced with the aid of most gases. The film structure may also be manufactured in the form of various multi-layer films, and particularly thin films are obtained by evaporating from the film a liquid that has been included in the film matrix prior to coating the film; extremely small gas blisters or bubbles are obtained in this way.



# Claims

1. A dielectric film element converting the energy of an electric or magnetic field into mechanical energy or converting mechanical energy into electric energy comprising a homogeneous elastic layer (A) containing gas blisters or cells (C), **characterized** in that said film has been stretched in two directions so as to flatten the blisters and form flat disk-like bubbles extending in a plane transverse to the direction of the intended movement and in that said film is at least partly coated with an electrically conductive layer (B) on at least one surface of the said layer (A).
2. A film element according to claim 1, **characterized** in that said layer (A) comprises a foamed plastics film of substantially full-cell type structure (C).
3. A film element according to claim 1 or 2, **characterized** by several layers of film joined together, such as by winding the film on a roll or folding it, thereby lengthening the motion distance.
4. A film element according to any of claims 1 to 3, **characterized** by four-pole current ( $I_1$ ) supply points and points ( $U_1$ - $U_4$ ) for connecting a measuring instrument for measuring the electric properties of the element and for producing a feedback signal for a control member (16) controlling the film element.
5. A film element according to claim 4, **characterized** by a piezoelectric film (13) attached to a surface of the film element, a signal corresponding to the pressure against the surface of the piezoelectric film (13) being used as a feedback signal for said control member (16) used in controlling the film element.
6. A film element according to claim 4 or 5, **characterized** therein, that the control member comprises a feedback coupled operation amplifier.
7. A film element according to claim 6, **characterized** therein that the operation amplifier is frequency selective.
8. A film element according to any of claims 1 to 7, **characterized** therein that said blisters (C) contain a ionizable gas and in that said independently addressable elements are provided in the conductive layer (B), said independently addressable elements being separately controllable for lighting up an area of the surface conforming to the lead pattern (2) formed by said conductive layer (B).
9. A film element according to claim 8, **characterized** in that the lead pattern (2) has been formed of a transparent, electrically conductive plastics material.
10. A procedure of manufacturing a dielectric film element according to claim 1, **characterized** by the steps of
  - a) extruding a foamable plastics material in a plastics processing machine to form a tube (23), gas blisters being formed due to the foaming at desired density throughout the tube,
  - b) heating the tube,
  - c) expanding the heated tube in two directions to obtain a desired wall thickness and orientation,
  - d) metallizing the outer surface of the tube, and
  - e) longitudinally cutting open the tube to form a film.
11. A procedure according to claim 10, **characterized** in that after extrusion the tube is subjected to intermediate cooling, whereafter it is heated before being expanded.
12. A procedure according to claim 10 or 11, **characterized** therein, that the metallizing of the outer surfaces is performed selectively so as to produce a given pattern.

## Revendications

1. Un élément de film diélectrique convertissant l'énergie d'un champ électrique ou magnétique en énergie mécanique ou convertissant l'énergie mécanique en énergie électrique, comprenant une couche élastique homogène (A) contenant des boursoufflures ou des cellules de gaz (C), caractérisé en

ce que ledit film a été étiré selon deux directions de façon à aplatir les boursoufflures et à former des bulles en forme en disques et s'étendant dans un plan transversal à la direction de déplacement à réaliser, et en ce que ledit film est au moins partiellement enrobé d'une couche électriquement conductrice (B) sur au moins une surface de ladite couche (A).

- 5 2. Un élément de film selon la revendication 1, caractérisé en ce que ladite couche (A) comprend un film en matière plastique alvéolaire présentant une structure sensiblement du type à cellule pleine (C).
- 10 3. Un élément de film selon la revendication 1 ou 2, caractérisé par plusieurs couches de film reliées entre elles, par exemple par bobinage du film sur un rouleau ou par pliage, de manière à allonger la distance de déplacement.
- 15 4. Un élément de film selon l'une quelconque des revendications 1 à 3, caractérisé par des bornes d'alimentation en courant ( $I_1$ ) à quatre pôles et des bornes ( $U_1$ - $U_4$ ) destinées à être reliées à un instrument de mesure pour mesurer les propriétés électriques de l'élément et pour envoyer un signal de réaction à un organe de contrôle (16) contrôlant l'élément de film.
- 20 5. Un élément de film selon la revendication 4, caractérisé par un film piézo-électrique (13) fixé à une surface de l'élément de film, un signal correspondant à la pression contre la surface du film piézo-électrique (13) étant utilisé comme signal de réaction pour ledit organe de contrôle (16) utilisé pour contrôler l'élément de film.
- 25 6. Un élément de film selon la revendication 4 ou 5, caractérisé en ce que l'organe de contrôle comporte un amplificateur opérationnel couplé en réaction.
7. Un élément de film selon la revendication 6, caractérisé en ce que l'amplificateur opérationnel est sélecteur de fréquence.
- 30 8. Un élément de film selon l'une quelconque des revendications 1 à 7, caractérisé en ce que lesdites boursoufflures (C) contiennent un gaz ionisable et en ce que lesdits éléments, adressables indépendamment, sont prévus dans la couche conductrice (B), lesdits éléments adressables indépendamment étant susceptibles d'être commandés séparément pour illuminer une zone de la surface s'adaptant au réseau de conducteurs (2) formé par ladite couche conductrice (B).
- 35 9. Un élément de film selon la revendication 8, caractérisé en ce que le réseau de conducteurs (2) est constitué d'une matière plastique transparente et électriquement conductrice.
- 40 10. Un procédé de fabrication d'un élément de film diélectrique selon la revendication 1, caractérisé en ce qu'il comporte les étapes consistant à:
  - a) extruder une matière plastique alvéolaire dans une machine de traitement de matière plastique afin de former un tube (23), des boursoufflures gazeuses étant formées par suite de l'obtention d'une structure alvéolaire de densité souhaitée sur toute la longueur du tube;
  - b) chauffer le tube;
  - 45 c) dilater le tube chauffé selon deux directions afin d'obtenir l'épaisseur de paroi et l'orientation souhaitées;
  - d) métalliser la surface extérieure du tube; et
  - e) ouvrir longitudinalement par découpe le tube afin de former un film.
- 50 11. Un procédé selon la revendication 10, caractérisé en ce qu'après extrusion, le tube est soumis à un refroidissement intermédiaire, à la suite duquel il est chauffé avant d'être dilaté.
12. Un procédé selon la revendication 10 ou 11, caractérisé en ce que la métallisation des surfaces extérieures se fait sélectivement de façon à réaliser un réseau prédéterminé.

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## Ansprüche

1. Dielektrisches Filmelement, das die Energie eines elektrischen oder magnetischen Feldes in mechani-

sche Energie oder mechanische Energie in elektrische Energie umwandelt, mit einer homogenen elastischen Schicht (A), die Gasblasen oder Zellen (C) aufweist, **dadurch gekennzeichnet**, daß der Film in zwei Richtungen gereckt worden ist, um die Gasblasen flach werden zu lassen und flache, scheibenförmige sich in einer Ebene quer zur gewollten Bewegungsrichtung erstreckende Blasen zu bilden und daß der Film zumindest teilweise mit einer elektrisch leitenden Schicht (B) auf zumindest einer Fläche der vorgenannten Schicht (A) beschichtet ist.

2. Filmelement nach Anspruch 1, **dadurch gekennzeichnet**, daß die erstgenannte Schicht (A) einen geschäumten Plastikfilm mit im wesentlichen Vollzellenstruktur (C) enthält.

3. Filmelement nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß mehrere Schichten des Films so aneinanderstoßen, daß beim Aufwickeln des Films auf eine Filmrolle oder bei seinem Falten der Bewegungsbereich vergrößert wird.

4. Filmelement nach einem der Ansprüche 1 bis 3, **gekennzeichnet**, durch Zuführungspunkte für die Zuführung eines vierpoligen Stroms ( $I_1$ ) und Punkte ( $U_1$ - $U_4$ ) zum Anschließen eines Meßgeräts zum Messen der elektrischen Eigenschaften des Elements und zum Erzeugen eines Rückführungssignals zu einem Steuerglied (16) zum Steuern des Filmelements.

5. Filmelement nach Anspruch 4, **gekennzeichnet** durch einen piezoelektrischen Film (13) in Zuordnung zu einer Fläche des Filmelements, ein Signal entsprechend dem Druck gegen die Fläche des piezoelektrischen Films (13) in der Verwendung als Rückführsignal zum Steuerglied (16) zum Steuern des Filmelements.

6. Filmelement nach Anspruch 4 oder 5, **dadurch gekennzeichnet**, daß das Steuerglied einen bei der Signalarückführung wirkenden Operationsverstärker enthält.

7. Filmelement nach Anspruch 6, **dadurch gekennzeichnet**, daß der Operationsverstärker frequenzselektiv ist.

8. Filmelement nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet**, daß die Blasen (C) ein ionisierbares Gas einschließen und daß die unabhängig ansprechbaren Elemente in der leitenden Schicht (B) angeordnet sind, wobei die unabhängig ansprechbaren Elemente separat steuerbar sind, um einen Bereich der Oberfläche in Übereinstimmung mit dem Führungsmuster (2) aufzuhellen, das von der leitenden Schicht (B) gebildet wird.

9. Filmelement nach Anspruch 8, **dadurch gekennzeichnet** daß das Führungsmuster (2) von transparentem, elektrisch leitendem Plastikmaterial gebildet wurde.

10. Verfahren zur Herstellung eines dielektrischen Filmelements gemäß Anspruch 1, **gekennzeichnet** durch folgende Verfahrensschritte:

a) Extrudieren eines schäumbaren Plastikmaterials in einer Plastikverarbeitungsmaschine zum Bilden eines Rohres (23), wobei auf das Rohr verteilte Gasblasen beim Schäumen zu gewollter Dicke gebildet werden,

b) Erhitzen des Rohres,

c) Expandieren des erhitzten Rohres in zwei Richtungen, um eine gewollte Wandstärke und Ausrichtung zu erhalten,

d) Metallisieren der Außenseite des Rohres und

e) Aufschneiden des Rohres in Längsrichtung, um so einen Film zu bilden.

11. Verfahren nach Anspruch 10, **dadurch gekennzeichnet**, daß das Rohr nach dem Extrudieren einer Zwischenkühlung unterworfen wird, worauf es vor dem Expandieren erhitzt wird.

12. Verfahren nach Anspruch 10 oder 11, **dadurch gekennzeichnet**, daß das Metallisieren der Außenseite des Rohres selektiv erfolgt, um ein vorgegebenes Muster zu erzeugen.

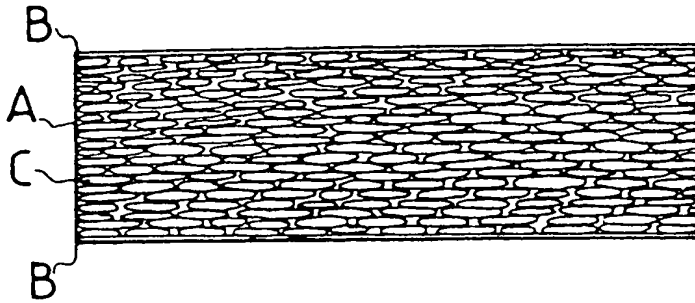


Fig. 1

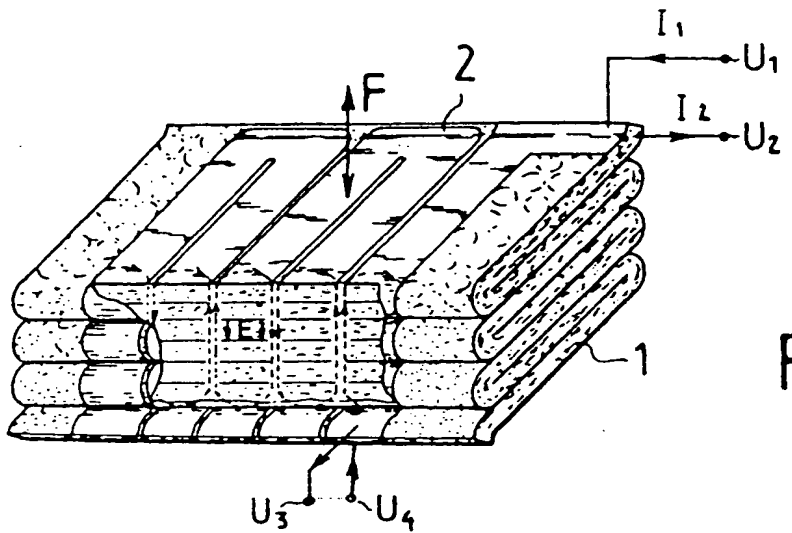


Fig. 2a

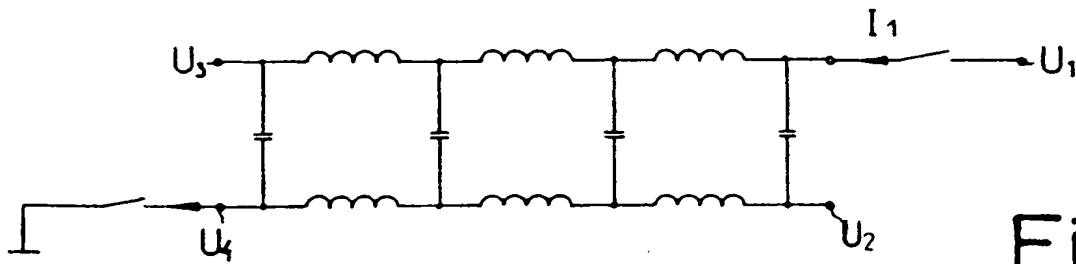


Fig. 2b

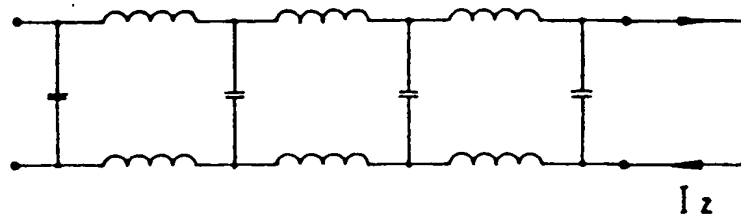


Fig. 2c

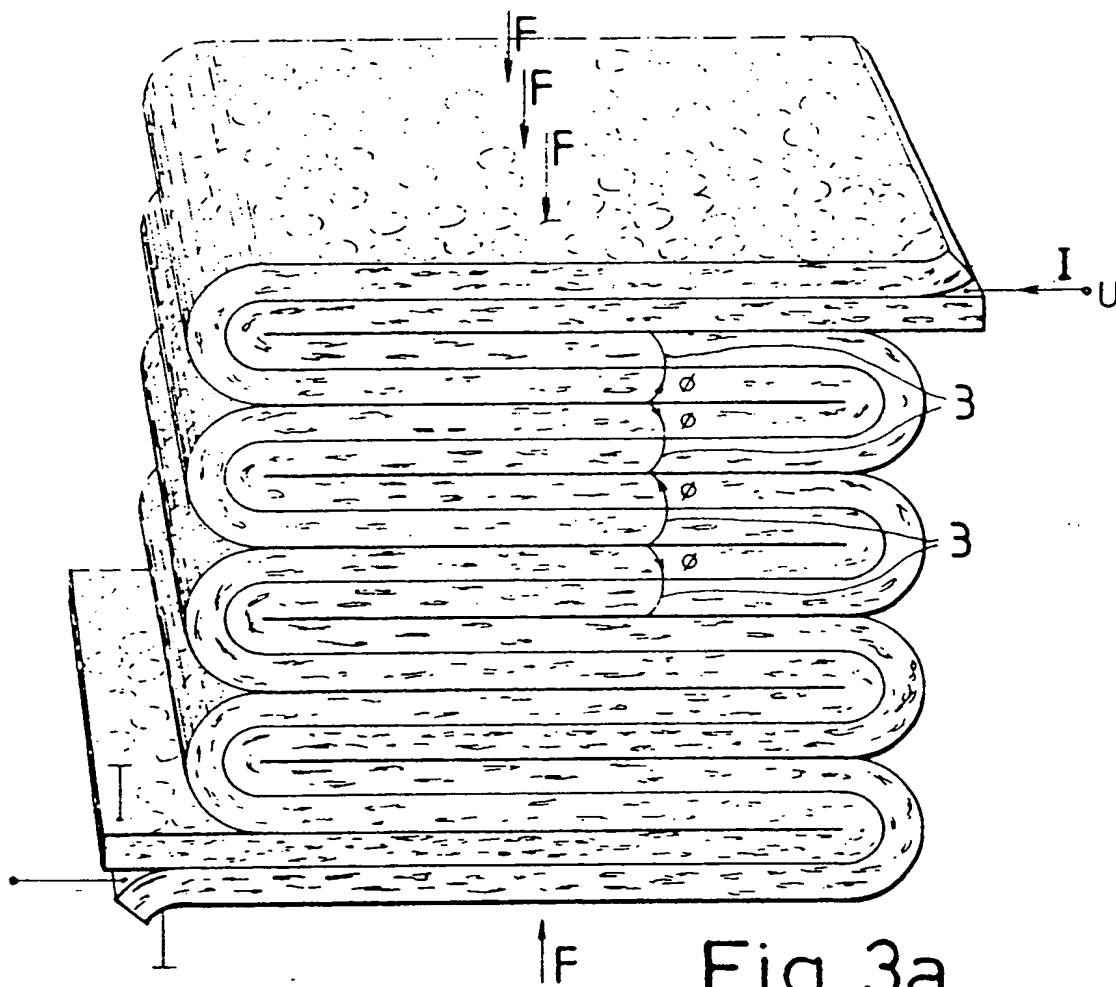


Fig. 3a

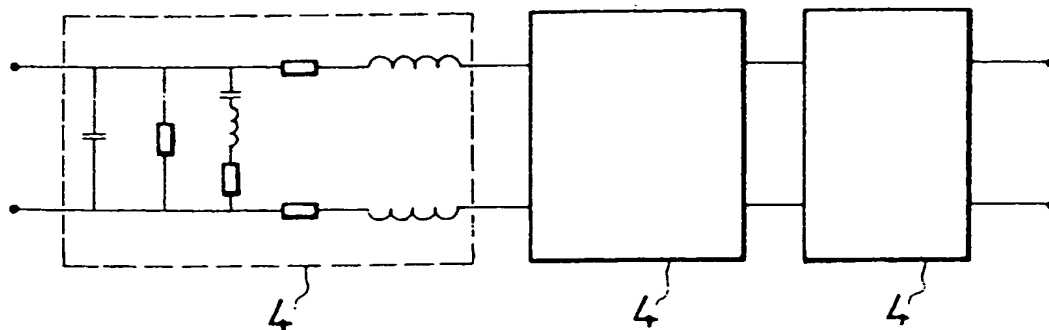


Fig. 3b

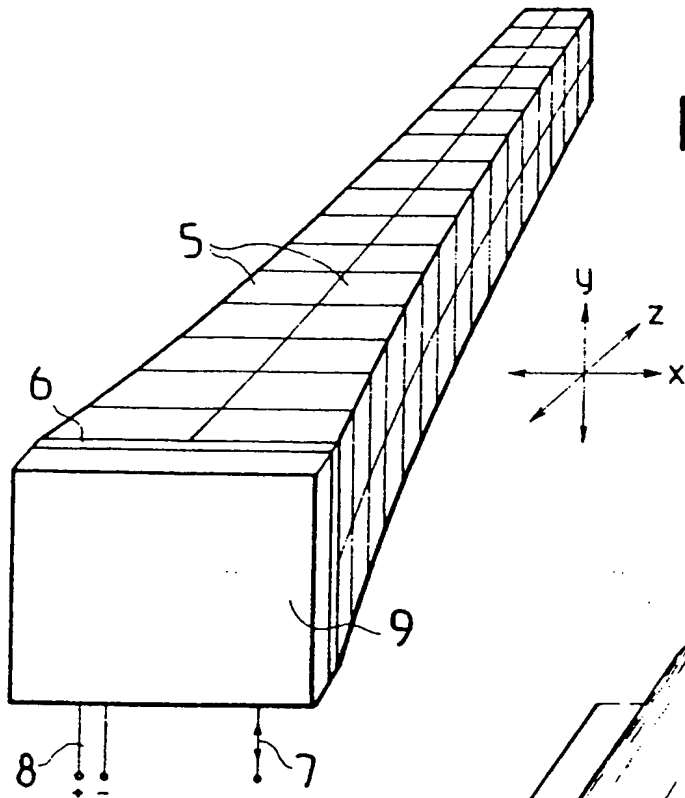


Fig. 4

Fig. 5a

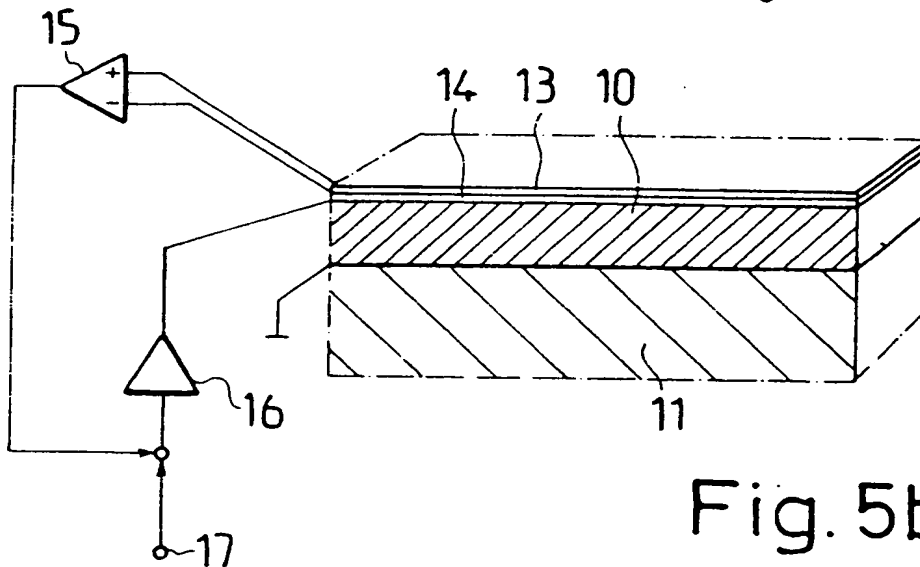
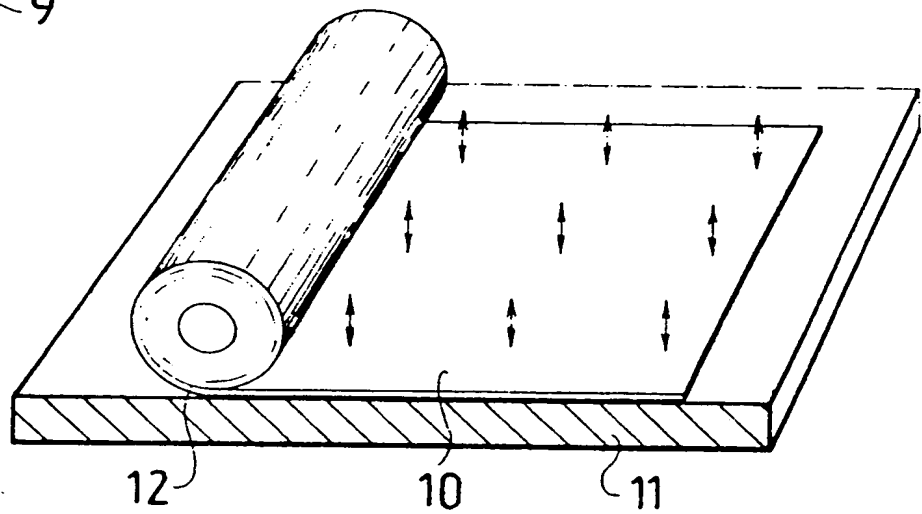


Fig. 5b

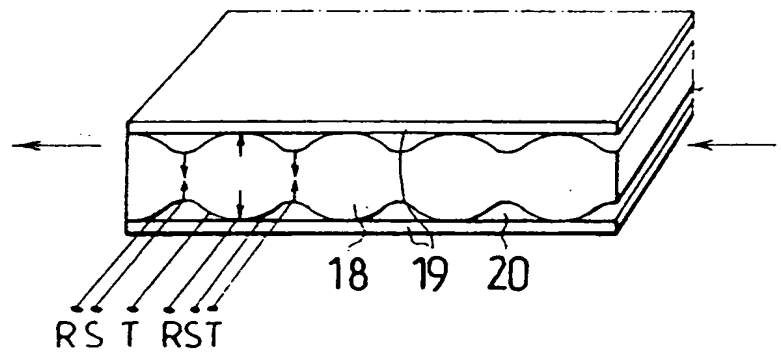
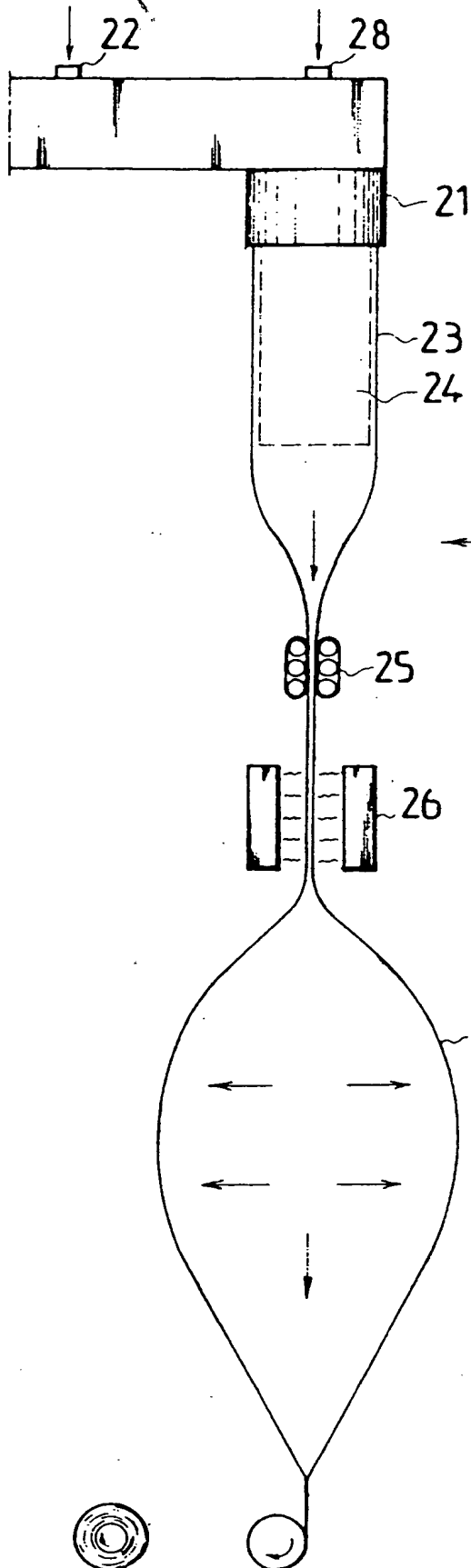


Fig.6

Fig.7

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